

SECTION 8- SHOULDER ASSEMBLY

8.1 Shoulder Assembly Description and Features

The shoulder assembly for the THOR dummy includes the mechanical components that connect the arms to the spine and thorax assemblies. The shoulder was designed to replicate the geometry and motion of the human shoulder / clavicle complex. A separate human-like clavicle linkage was used to provide a more biofidelic interaction between the shoulder assembly and belt restraint systems. This separate clavicle can load the sternum and rib cage directly to produce a more human-like loading condition. The shoulder was designed as a four-part linkage in which the shoulder block acts like the scapula to connect the linkage to the spine. This block is connected to the shoulder joint through a rotation joint. The shoulder joint is also connected to the clavicle, which is in turn connected to the sternum. The shoulder joint has been designed as a two-axis rotation system which provides motion similar to the human ball joint. Soft stops have been provided to limit the range of motion to meet the human design specifications provided by SAE.

Motion in the shoulder structure was provided in the fore and aft, as well as the shrugging directions. The shoulder assembly for THOR has been designed to accept the standard Hybrid III 50% male dummy arms which allow many test labs to retro-fit arms from older dummies onto the new units. The complete shoulder assembly can be seen in **Figure 8.1**.

One of the primary goals of the new shoulder assembly was to provide a more human-like interaction between the shoulder belt restraint and the dummy. The shoulder was designed with an integrated shoulder pad which conforms closely to the human shoulder geometry and helps to create proper interaction between the belt and the clavicle.

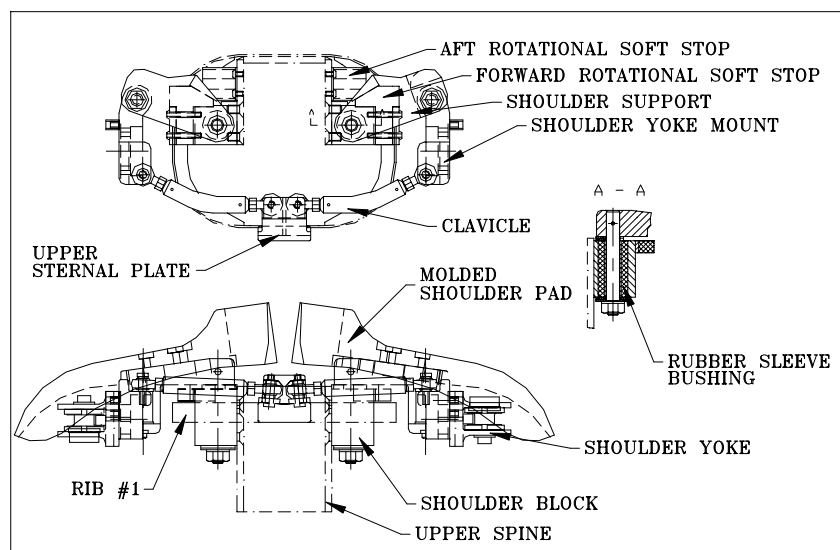


Figure 8.1- Complete shoulder assembly

8.2 Shoulder Assembly

8.2.1 Parts List

The parts list and all quantities for the shoulder assembly are listed in Appendix I - Bill of Materials under the Shoulder subsection. Refer to drawing T1SHM000 in the THOR drawing set for a detailed mechanical assembly drawing. **Figure 8.2** is a drawing of the exploded shoulder assembly without Molded Shoulder Pads (T1SHS100).

8.2.2 Assembling the Shoulder Components

The following procedure is a step-by-step description of the assembly procedure for all shoulder components. The numbers noted in () refer to a specific drawing / part number for each part. The numbers noted in the { } indicate the hex wrench size required to perform that step of the assembly. All bolts should be tightened to the torque specifications provided in Section 2.1.3- Bolt Torque Values.

1. Position a Sternum / Clavicle Washer (T1SHM010) on both sides of the right Clavicle Assembly (T1SHM002) ball end joints. Position the ball end joint and washers into the recess on the back right side of the Upper Sternal Plate (T1SHM018), and secure the clavicle with a Sternal / Clavicle Bolt (T1SHM011) {3/16} inserted from the bottom side, as shown in **Figure 8.3**.

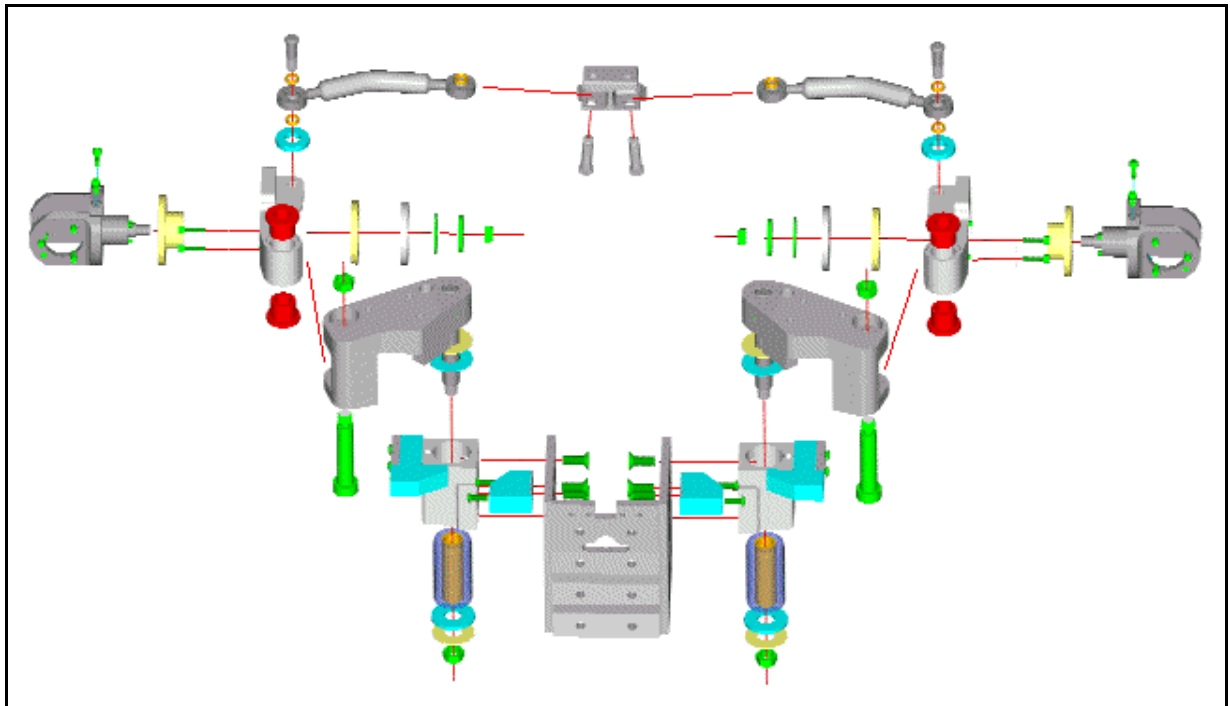


Figure 8.2- Shoulder assembly exploded view

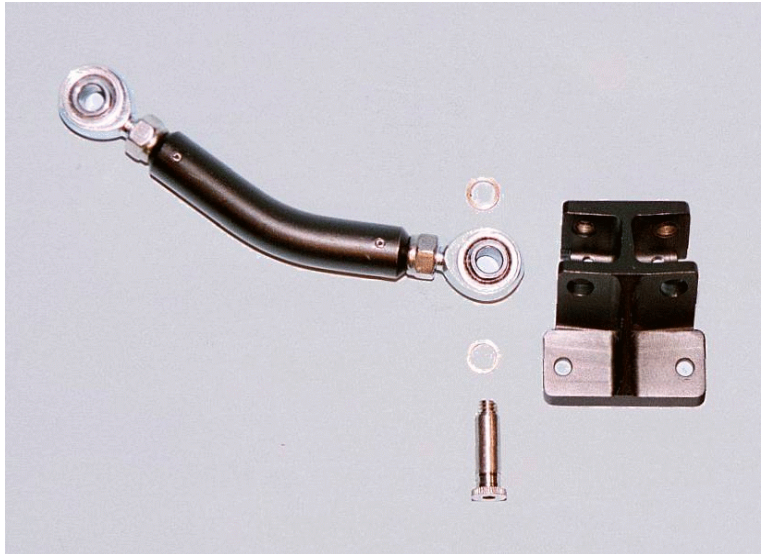


Figure 8.3- Upper Sternum / clavicle exploded assembly

2. Repeat step one for the left clavicle assembly. The completed clavicle / upper sternum assembly is shown in **Figure 8.4**.

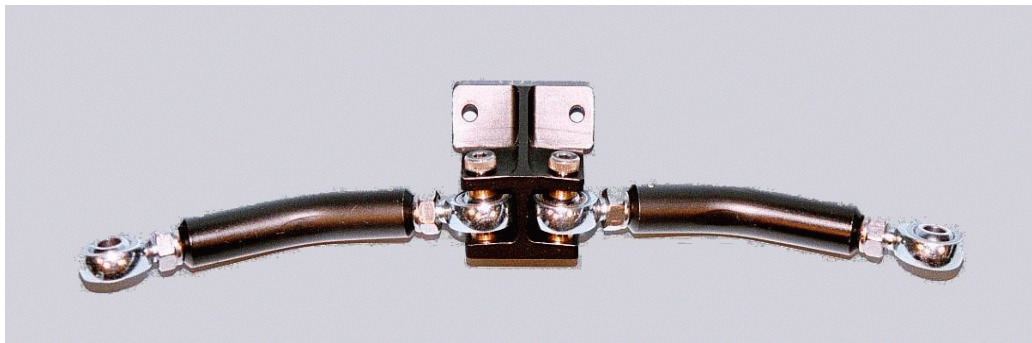


Figure 8.4- Assembled Clavicle /Upper Sternum

3. Position a Yoke Mount / Clavicle Washer (T1SHM010) on both sides of the right Clavicle Assembly (T1SHM002) ball end joint. Position a Rubber Washer (T1SHM036) over the clavicle mounting hole in the Right Shoulder Yoke Mount Assembly (T1SHM007). Secure the clavicle with a Yoke Mount / Clavicle Bolt (T1SHM016) {3/16}, as shown in **Figure 8.5**.

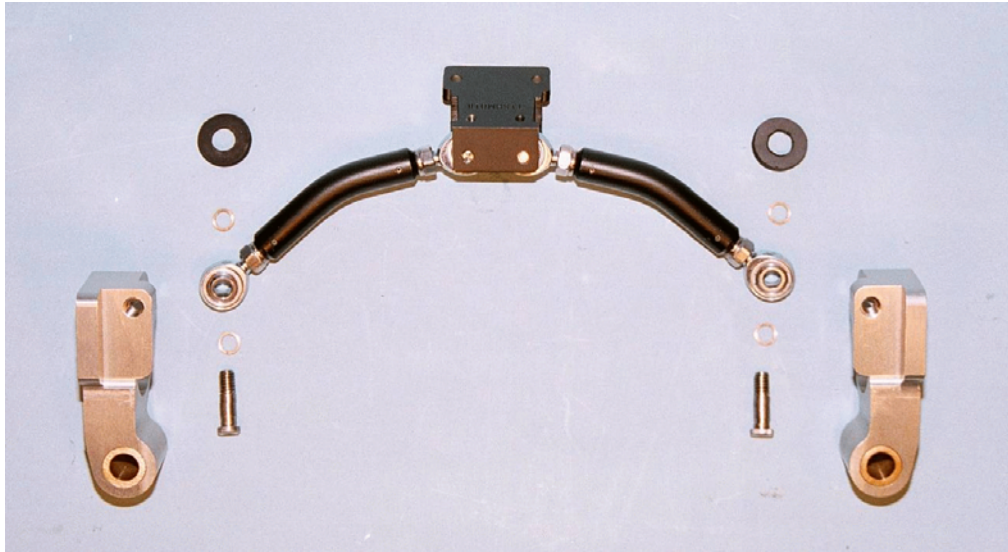


Figure 8.5- Clavicle / yoke mount exploded assembly

4. Repeat step three to attach the left clavicle assembly to the Left Shoulder Yoke Mount Assembly (T1SHM006). The completed Clavicle / Yoke mount assembly is shown in **Figure 8.6**.

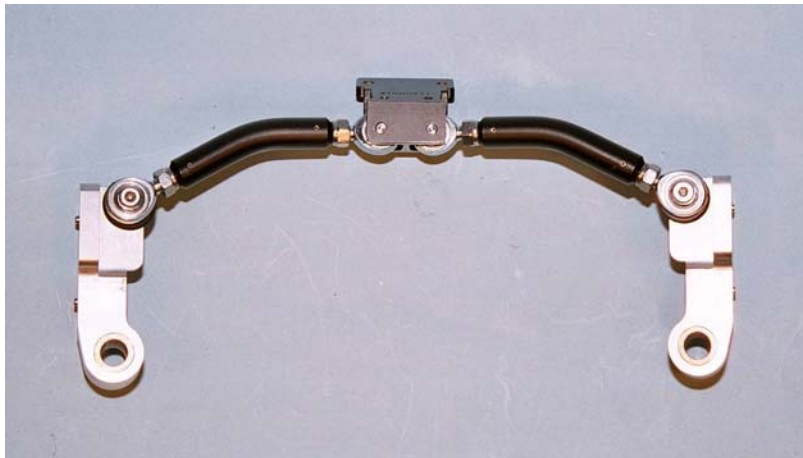


Figure 8.6- Assembled Clavicle /Yoke mount

5. Slide the Left Shoulder Yoke Mount Assembly (T1SHM006) into the machined slot on the Left Shoulder Support (T1SHM022). Insert the $\frac{1}{2}$ - 1.75" shoulder bolt {1/4} through the assembly from the bottom and tighten into the left shoulder support. Secure the shoulder bolt with a flat washer (3/8" ID, 7/8" OD) and a 3/8 - 16 nylock nut {9/16}. An exploded view of this assembly is shown in **Figure 8.7**.

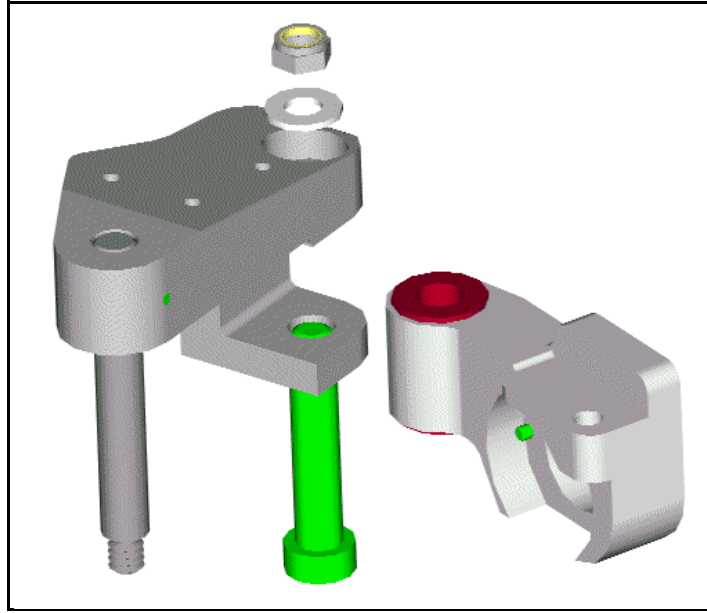


Figure 8.7- Step 5 shoulder assembly

6. Repeat step five to attach the Right Shoulder Yoke Mount Assembly (T1SHM007) to the Right Shoulder Support (T1SHM023). The completed yoke mount / shoulder support assembly is shown in **Figure 8.8**.



Figure 8.8- Shoulder assembly completed to this point

7. **Figure 8.9** shows an exploded view of the shoulder block assemblies. The shoulder block assembly is started by inserting one of the Molded Rubber Sleeve Assemblies (T1SHM003) into the bored hole in the Right Shoulder Block (T1SHM015).

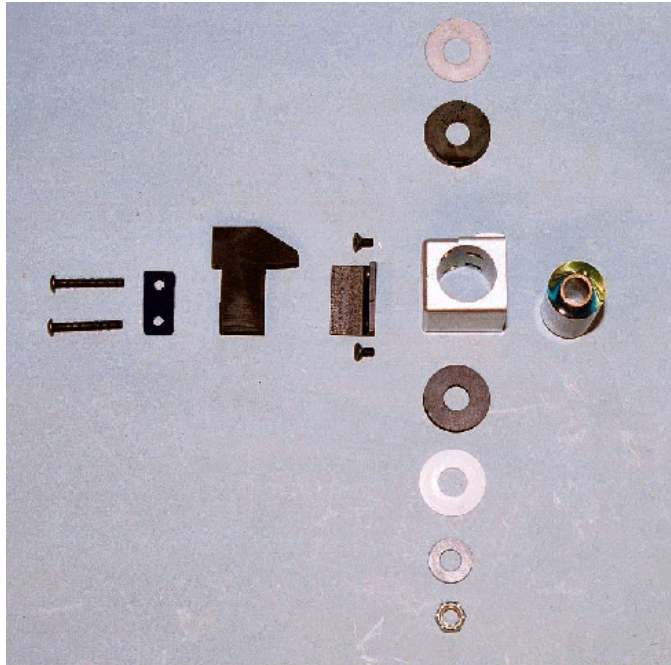


Figure 8.9- Exploded Shoulder Block Assembly

8. Attach the Rib Support Bracket (T1SPM113) on the lower set of mounting holes on the right shoulder block using two #10-32 x 3/8" FHSCS {1/8}, as shown in **Figure 8.10**.

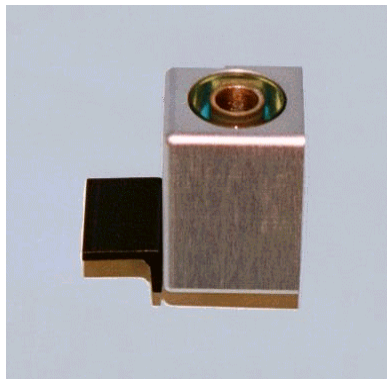


Figure 8.10- Rib support shelf mounted

9. Attach the Shoulder Inner Stop Bumper (T1SHM024) and the Inner-Stop End Plate (T1SHM012) to the top set of mounting holes on the right shoulder block using two #10-32 x 1.375" BHSCS {1/8}. This completes the assembly for the right shoulder block, as shown in **Figure 8.11**.

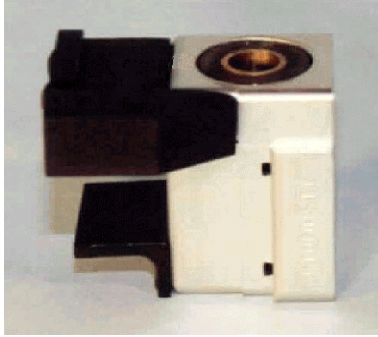


Figure 8.11- Inner stop bumper assembled to shoulder block

10. Repeat Steps 7 through 9 for the Left Shoulder Block (T1SHM014) assembly. The completed shoulder block assemblies are shown in **Figure 8.12**.

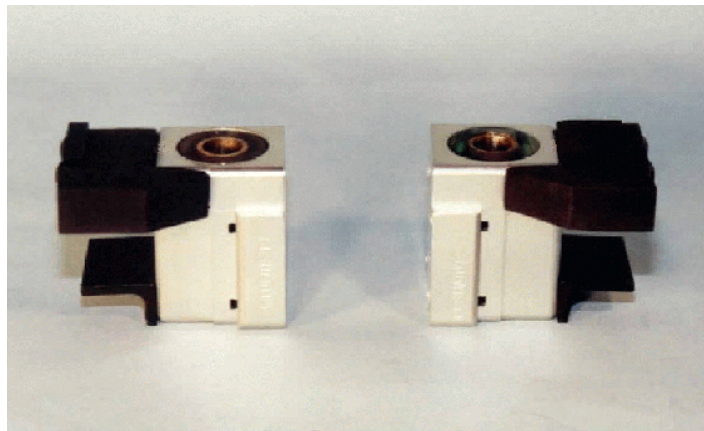


Figure 8.12- Completed shoulder block assembly

11. **Figure 8.13** shows an exploded view of the completed right shoulder block assembly attached to the right shoulder support. Position in the following order, a Yoke Washer (T1SHM028) and a Rubber Washer I (T1SHM030) over the Shoulder Shaft (T1SHM035) that is attached to the Right Shoulder Support (T1SHM023). Insert the assembly into the right shoulder block assembly and place in the following order, a Rubber Washer I, a Yoke Washer, a flat washer (1.25" OD, 13/32" ID), and a 3/8-16 nylock nut {9/16} on the opposite end of the Shoulder Shaft.

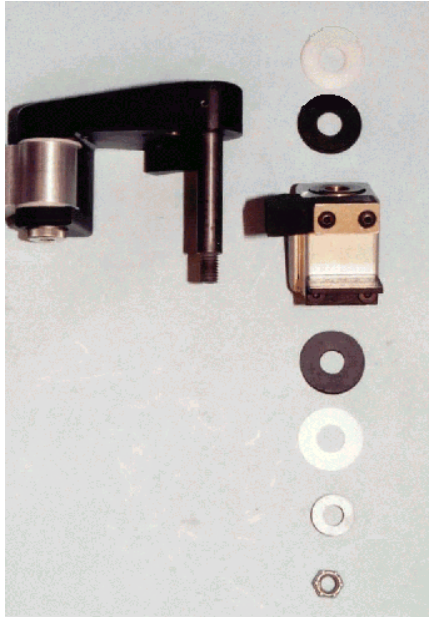


Figure 8.13- Exploded shoulder block to support assembly

12. Repeat Step 11 for the left shoulder block assembly attached to the left shoulder support. The shoulder block / shoulder support assembly is shown in **Figure 8.14**.



Figure 8.14- Completed shoulder assembly to this point

13. Attach the Outer Stop Assemblies (T1SHM008) to the Upper Thoracic Spine Weldment (T1SPW100) using four #10-32 x 1/2" BHSCS {1/8}, as shown in **Figure 8.15**. The angled sides of the stop faces the front of the dummy.

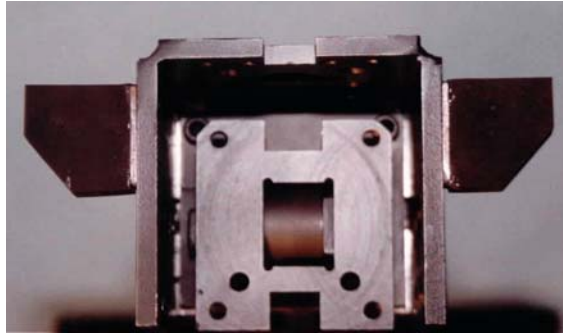


Figure 8.15- Outer stop assembly on UTS weldment

14. Attach the shoulder assembly to the upper thoracic spine weldment using four 5/16-24 x 3/4" FHSCS {3/16} on each side. The bolts are tightened from inside the Upper Thoracic Spine Weldment (T1SPW100). The shoulder mounting bolts are shown in **Figure 8.16**.

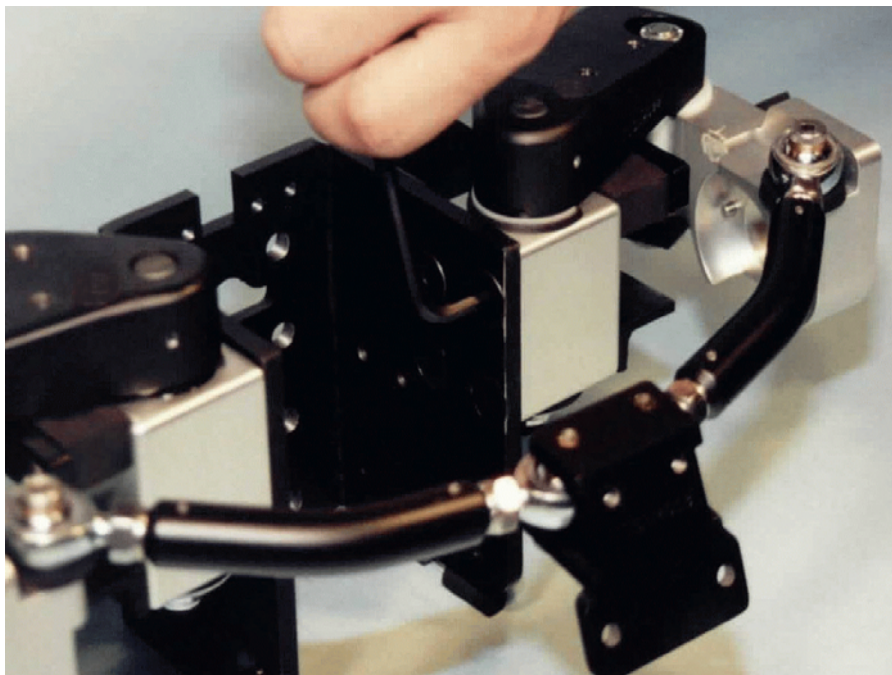


Figure 8.16- Shoulder assembly mounted on the UTS weldment

15. Attach a Shoulder Pivot Stop Assembly (T1SHM004) to the outer side of both the left and right Shoulder Yoke Mount Assemblies (T1SHM006 & T1SHM007) using two #8-32 x 5/8" SHCS {9/64} on each side. These pivot stops maintain the proper range of motion for the shoulder in this rotation. The location of the stops are shown in **Figure 8.17**.

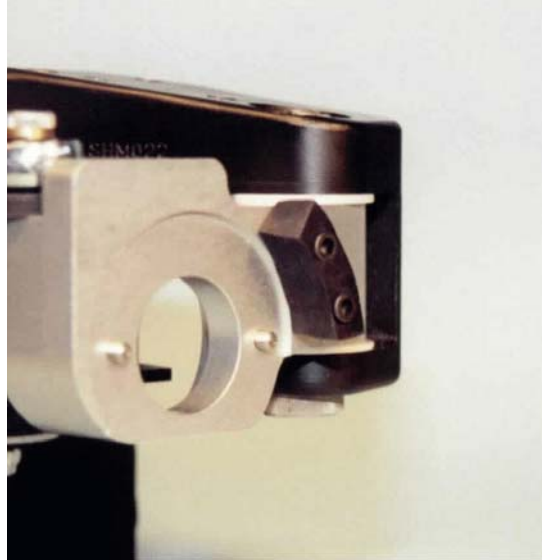


Figure 8.17- Shoulder pivot stop location

16. Attach a Steel Pivot Stop (T1SHM046) to the Left and Right Shoulder Yoke Assemblies (T1SHM005) using two #8-32 x 3/8" SHCS {9/64} on each side. The location of the stops are shown in **Figure 8.18**.



Figure 8.18- Steel pivot stop on yoke

17. **Figure 8.19** is an exploded view showing the assembly of the shoulder yoke assembly to the shoulder yoke mount. Position one Shoulder Yoke Pivot Bushing (T1SHM038) into each shoulder yoke mount assembly from the outer side. The two holes in the shoulder yoke pivot bushings should engage the dowel pins in the yoke mount assemblies.

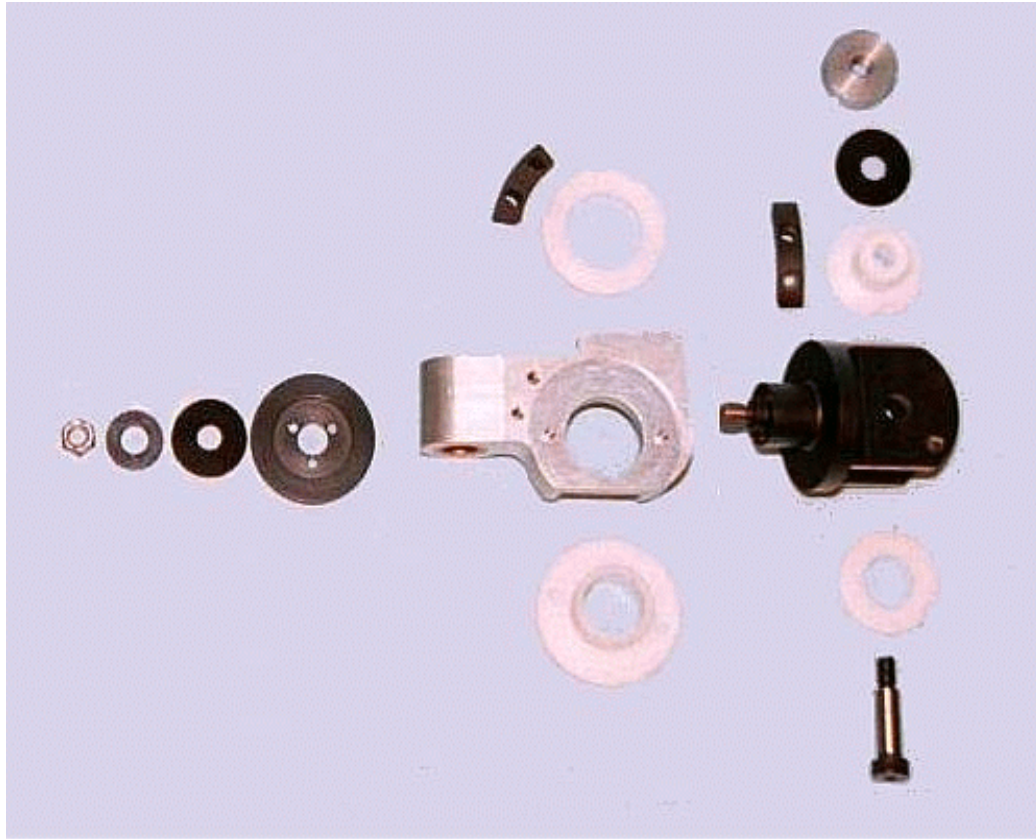


Figure 8.19- Exploded shoulder yoke to yoke mount assembly

18. Position one Shoulder Yoke Delrin Washer (T1SHM027) into each shoulder yoke mount assembly from the inner side. The two holes in the shoulder yoke Delrin washer should engage the dowel pins in the yoke mount assemblies.
19. Insert one Shoulder Yoke (T1SHM005) into the shoulder yoke mount from the outside. Position the Shoulder Yoke Steel Washer (T1SHM026) on the shoulder yoke with the counter bore facing away from the shoulder yoke. Align the holes with the three dowel pins on the shoulder yoke.
20. Place one Shoulder Joint Spring Washer (T1SHM037) over the end of each shoulder yoke. Secure the yoke with a flat steel washer (1 1/8" OD, 11/32" ID) and a 5/16-18 nylock hex nut $\{ \frac{1}{2} \}$. This completed assembly is shown in **Figure 8.20**. Tighten the nut to provide a joint resistive torque of 1 g.

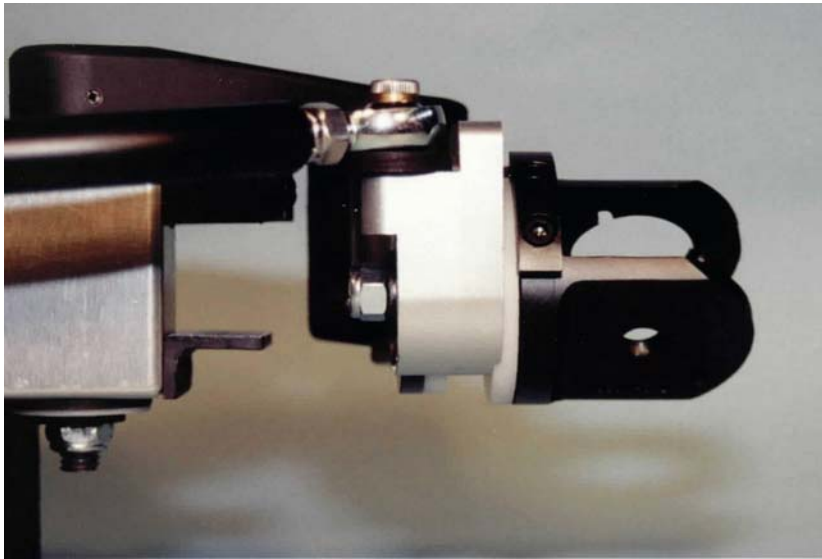


Figure 8.20- Shoulder yoke assembled to yoke mount

21. **Figure 8.21** shows an exploded view of the upper arm / shoulder assembly. Position one Upper Arm Pivot Bushing (T1SHM040) and one Upper Arm Pivot Washer (T1SHM041) onto the top of a standard Hybrid III arm assembly. Place a Upper Arm Joint Spring Washer (T1SHM047) into the recessed area of the pivot bushing. Position the upper arm assembly into the shoulder yoke. (Be sure to use the appropriate arm for each side of the dummy.) The joint spring washer should be facing out toward the large hole opening in the shoulder yoke. Rotate the upper arm pivot bushing and the upper arm pivot washer until the notches are aligned with the dowel pins in the shoulder yoke.
22. Place a flat washer (7/8" OD, 13/32" ID) onto a 3/8 x 1" shoulder bolt and insert it through the arm / bushing assembly. Position the Pivot Nut (T1SHM042) into the large bore in the side of the shoulder yoke and align the grooves on the nut with the dowel pins. Tighten the shoulder bolt into the pivot nut and adjust the arm to a 1 g resistive torque.

NOTE: The pivot nut should be placed directly over the joint spring washer to allow effective adjustment of the arm resistive torque.

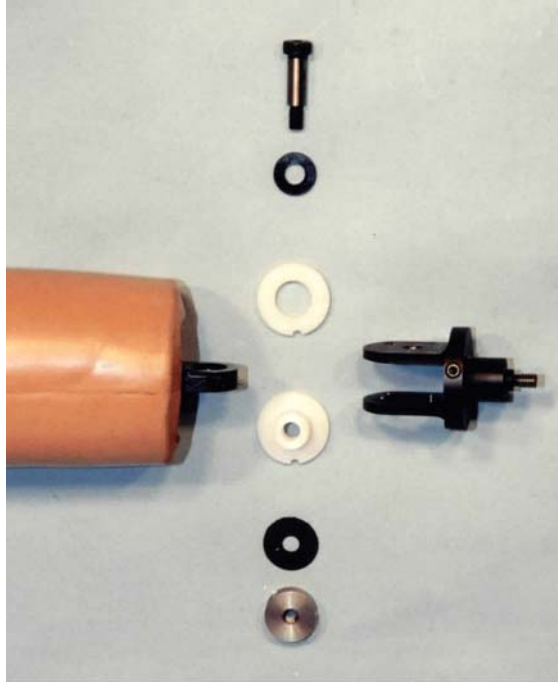


Figure 8.21- Exploded arm attachment assembly

23. Position the Neck Shroud Support (T1SHM048) around the top of the upper thoracic spine box and secure it, using two #10-32 x 1/2" BHSCS {1/8}, as shown in **Figure 8.22**.

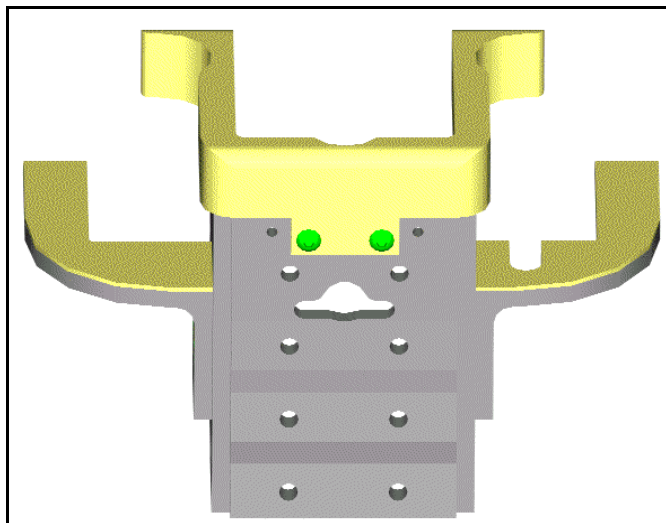


Figure 8.22- Neck shroud support installed

24. Attach the Right and Left Molded Shoulder Pads (T1SHS110 & T1SHS111) to the top of the shoulder supports, using three 1/4-20 x 1" flanged BHSCS {5/32} on each side, as shown in **Figure 8.23**.

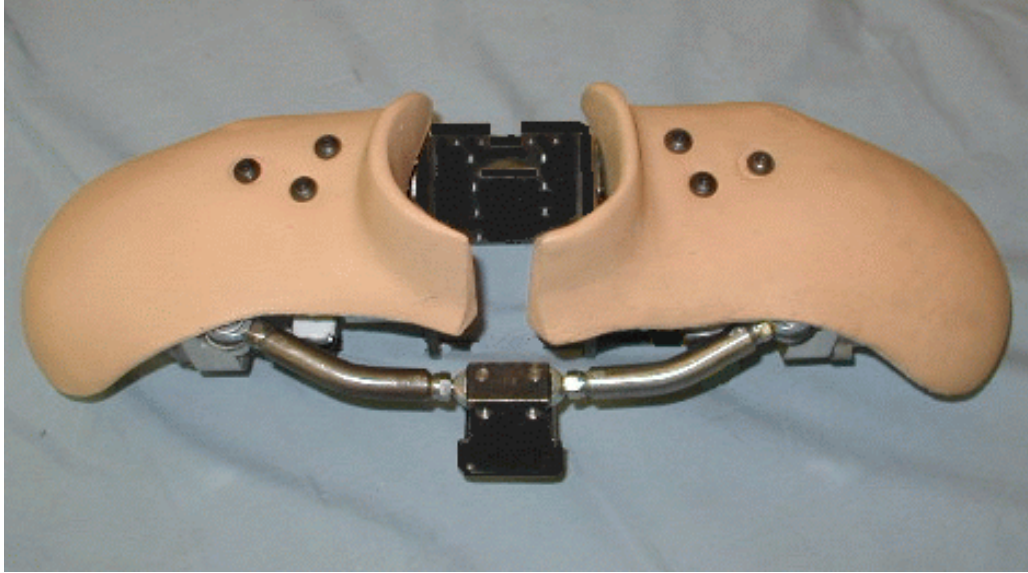


Figure 8.23- Shoulder Pads attached to shoulder assembly

8.2.3 Connecting the Shoulders to the Spine

The following procedure is a step-by-step description used to connect the shoulder assembly to the completed spine assembly (T1SPM000). The numbers provided in () refer to a specific drawing / part number of each part. The numbers noted in { } after the bolt size indicate the hex wrench size required to perform that step of the assembly. All bolts should be tightened to the torque specifications provided in Section 2.1.3- Bolt Torque Values. For additional details, refer to Section 7.2.1, Steps 13 and 14.

1. Remove the rib support shelves from the upper thoracic spine. Remove the head and neck assembly if necessary.
2. Attach the Outer Stop Assembly (T1SHM008) to the Upper Thoracic Spine Weldment (T1SPW100) using two #10-32 x 1/2" BHSCS {1/8}. The angled side of the stop faces the front of the dummy.
3. Attach the shoulder assembly to the upper thoracic spine weldment using four 5/16-24 x 3/4" FHSCS {3/16} on each side. The bolts are tightened from inside the Upper Thoracic Spine Weldment (T1SPW100).
4. Replace the rib support shelves from the dummy's upper thoracic spine.

8.2.4 Connecting the Arms to the Shoulders

The following procedure is a step-by-step description used to connect the Hybrid III 50% Male Arm Assemblies to the completed shoulder assembly. The numbers provided in () refer to a specific drawing / part number of each part. The numbers noted in { } after the bolt size indicate the hex wrench size required to perform that step of the assembly. All bolts should be tightened to the torque specifications provided in Section 2.1.3- Bolt Torque Values. For additional details refer to Section 7.2.1.

1. Position one Upper Arm Pivot Bushing (T1SHM040) and one Upper Arm Pivot Washer (T1SHM041) onto the top clevis of a standard Hybrid III 50% male arm assembly. Place a Upper Arm Joint Spring Washer (T1SHM047) into the recessed area of the pivot bushing. Position the upper arm assembly into the shoulder yoke. (Be sure to use the appropriate arm for each side of the dummy.)

NOTE: The joint spring washer should be facing out toward the large hole opening in the shoulder yoke.

2. Rotate the upper arm pivot bushing and the upper arm pivot washer until the notches are aligned with the dowel pins in the shoulder yoke and the assembly is centered in the yoke.
3. Position the Pivot Nut (T1SHM042) into the large bore in the side of the shoulder yoke and align the grooves on the nut with the dowel pins.

NOTE : The pivot nut should be placed directly over the joint spring washer to allow effective adjustment of the arm resistive torque.

4. Place a flat washer (7/8" OD, 13/32" ID) onto a 3/8 x 1" shoulder bolt and insert it through the arm / bushing assembly. Tighten the shoulder bolt into the pivot nut and adjust the arm to a 1 g resistive torque.

8.3 Adjustments for the Shoulder Assembly

The shoulder assembly requires two joint resistive torque adjustments. The goal of the adjustment is to provide a 1 g joint friction torque.

- C The adjustment of the flexion shoulder motion is described in Section 8.2.2, Step 20. Check the adjustment by straightening the arm and raising it in front of the dummy. The arm should remain in position, but move easily under external force.
- C The adjustment of the abduction and adduction motion is described in Section 8.2.2, Step 22. Check the adjustment by straightening the arm and raising it to the side of the dummy. The arm should remain in position, but move easily under external force.

8.4 Electrical Connections and Requirements

No electrical connections are required for the shoulder assembly.

8.5 Shoulder Certification

No certification is required for the shoulder assembly.

8.6 Inspection and Repairs

After a test or test series has been performed, electrical and mechanical inspections must be made to ensure that the dummy's integrity has remained intact. These inspections are most easily carried out during disassembly of the dummy. The disassembly of the shoulder components can be performed by simply reversing the assembly procedure.

Although this disassembly is very simple, some comments are provided below to assist in the process.

8.6.1 Electrical Inspections (Instrumentation Check)

There are no instruments in the shoulder assembly.

8.6.2 Mechanical Inspection

Several components in the shoulder assembly will need a visual inspection to determine if they are still functioning properly. This mechanical inspection should also involve a quick check for any loose bolts in the main assembly. Each area of mechanical inspection will be covered in detail below. Please contact the manufacturer regarding questions about items that fail the mechanical inspection.

Shoulder Soft Stops: The following checklist should be used when inspecting the shoulder soft stops for post-test damage:

- C Check the inner soft stop assemblies for debonding between the rubber and the steel mounting plates
- C Check both soft stops for tearing or permanent compression

Shoulder Pads: The following checklist should be used when inspecting the shoulder pads for post-test damage:

- C Check the shoulder pads for damage (tearing, cuts, etc.) which may be caused by the belt loading.

Friction Joint Adjustments: The following checklist should be used when inspecting the shoulder pads for post-test damage:

- C Check the two rotation joints at the shoulder for the proper resistive torque. Refer to Section 2.9- Joint Resistive Torque Adjustments for further details.